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Diurnal and Seasonal Flight Activity of the Honeybee, *Apis mellifera* L, and its Relationship with Temperature, Light Intensity and Relative Humidity in the Savanna of Northern Nigeria

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DIURNAL AND SEASONAL FLIGHT ACTIVITY OF THE HONEYBEE, APIS MELLIFERA L, AND ITS RELATIONSHIP WITH TEMPERATURE, LIGHT INTENSITY AND RELATIVE HUMIDITY IN THE SAVANNA OF NORTHERN NIGERIA

Strictly as per the compliance and regulations of :

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Abstract - This study was carried out at Bauchi (10°19'N; 09°50'E; Elevation 520 m), Nigeria, and it was the first of its kind in the country. Number of foraging bees returning to the hive was recorded for five minutes, at intervals of 30 minutes, and used as an indicator of flight activity. Temperature, light intensity and relative humidity were recorded concurrently. Two peaks of flight activity (one just before sunrise and the other just before sunset), separated by a period of very low activity, were observed in the dry season. However, in the rainy season flight activity was high throughout the day, declining progressively towards sunset. Though there was no significant correlation (P>0.05) between flight activity and temperature at 25°C, an inverse and highly significant correlation (r=-0.75; P<0.01) was found between them at 35°C. Similarly, an inverse and highly significant correlation (r=-0.87; P<0.001) was observed between flight activity and light intensity. No correlation (r = 0.275; P = 0.441) was found between flight activity and relative humidity. The observed differences in flight activity appeared to be due to environmental factors such as temperature, light intensity and, most importantly, availability of forage rather than the genetic characteristics of the bee.

Keywords : savanna, flight activity, foraging activity, apis mellifera, honeybee, temperature, light intensity, relative humidity, nigeria.

I. Introduction

The honeybee, *A. mellifera*, depends wholly on plants for food. Honeybee workers make thousands of visits to flowers in order to collect nectar and pollen. They also collect propolis from plants, which they use, among other things, in plastering the interior of their nests. Water is collected to dilute honey and to cool the nest during hot weather. Thus, a honeybee colony necessarily lives a busy life. However, the level of activity depends on a number of factors, such as weather, availability of forage and size of the colony. People who work with bees, such as beekeepers and researchers, need to know the pattern of activity of their bees so that they can work at the appropriate time. In the same vein, this knowledge can be used to advise farmers on the appropriate time to spray their crops to avoid killing these beneficial insects while they pollinate these crops.

Investigations into the pattern of activity of various races of *A. mellifera,* in different parts of the world, reveal a lot of variation. For example, Woyke (1992) reported a single peak (in the morning) and two peaks (one after sunrise and one before sunset) of foraging activity for, *A.m. adansonii*, in the rainy and dry seasons, respectively, in Ghana. Similarly Fletcher (1978) reported one peak of activity for *A.m.scutellata* before sunrise in S Africa. On the other hand, Silva and de Jong (1990) reported three peaks (at 7.00, 14.00 and 16.00 h) of activity for Africanized bees in Brazil. Gary (1967) associated the U-shaped pattern of foraging activity he obtained to the high temperature and low humidity conditions of the desert environment. Danka and Beaman (2007), working in the U.S.A., found that Russian and Italian bees had similar flight activity at any given colony size, temperature, or time of day. Flight increased linearly with rising emperatures and larger colony sizes.

The objective of the study was to determine, for the first time, the pattern of diurnal flight activity of different colonies of the indigenous honeybee, *A. mellifera*, and its relationship with seasons, temperature, light intensity and relative humidity, in the Sudan savanna vegetation zone of northern Nigeria.

II. Materials and Methods

a) *The Study Area*

The study was carried out at Bauchi (9°50 E; 10°19 N; 620 m Above Sea Level) in northern Nigeria in the Sudan (dry) savanna, a belt of vegetation that extends from Senegal to Sudan (Hepburn and Radloff, 1998). The average annual temperature and rainfall are

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Global Journal of Science Frontier Research (C) Volume XIII Issue IV Version I Year 2013

25.4°C and 981 mm, respectively. There are two main seasons: a rainy season from May to October and a dry season from November to April (Dukku, 2003).

b) Diurnal Flight Activity

In order to determine the daily flight (or foraging) activity, foraging bees, returning within five minutes, were counted manually, with a tally counter, at the hive entrance, at intervals of 30 minutes, from dawn to dusk. The mean of the two counts within each hour was then used as a measure of flight activity of the colony for that hour. Temperature, light intensity and relative humidity were measured concurrently. In order to obtain seasonal foraging patterns, observations were made on five randomly-picked days for each of the rainy and dry seasons.

c) Data Analysis

Correlation analysis, t-test and one-way analysis of variance (ANOVA) were carried out on the generated data, as appropriate, using the statistical software, MINITAB 15 (Anonymous 2007).

III. Results

a) General Observations

Foraging commenced at dawn, and continued throughout the day, although at varying levels of intensity, irrespective of the honeybee colony or the season, and ended at dusk. Foraging ceased between 15 and 25 minutes after sunset when the intensity of light was 3 or 4 lx. Returning foragers flew straight into the hive or, occasionally, hovered for a while before entering: In either case the landing board was not used. Sometimes they missed the entrance and struck the hive or its support and then crawled in. Thin clouds did not prevent foraging but thick ones did. Bees were observed foraging during light rainfall.

b) Diurnal Flight Activity of Honeybee Colonies within Seasons

Figures 1 and 2 show the pattern of flight activity of two honeybee colonies (#Y1H and Y3H) located at the same site in the dry and rainy seasons, respectively. As could be seen from these figures, the colonies had a similar pattern within each season, though the patterns of the same colony differed between seasons.

c) Diurnal Flight Activity of Honeybee Colonies between Seasons

Flight activity of *A. mellifera* in the dry and rainy seasons is presented in Figure 3. The mean number of returning foragers for the dry and rainy seasons was 258 ± s.e. 83 (n = 13) and 450 ± s.e. 58 (n = 13) per hour, respectively. The difference between these two means was not significant (P>0.05). However, the activity of the bees in the dry season was more variable, with a coefficient of variation (CV) of 115.5%, than in the rainy season which had a CV of 83.6%. By contrast, the rainy season had high flight activity at 08.00 h (mean number or foragers = 715) and 9.00 h (mean number or foragers = 709) with a steady decline thereafter towards the evening.

d) Effect of Temperature on Flight Activity

There was no significant correlation (r = +0.311; P = 0.30) between temperature and number of returning foragers on 24th October, 1999 when temperature averaged 24.7±s.e.0.8°C (n=13) and ranged from 19 to 28°C. On 5th February, 2000 there was a significant, albeit weak, inverse correlation (r = -0.575; P = 0.04) between these two variables at an average temperature of 23.1±s.e.1.3°C (n=13; range= 14 - 29°C). However, on 3rd April, 2011, there was a strong inverse correlation (r = -0.748; P= 0.003) between temperature and number of foragers at an average temperature of 34.7±s.e.1.6°C (n=13; range= 21 - 41°C). A one way analysis of variance (ANOVA) revealed a highly significant (P < 0.001) difference between these three mean temperatures and Tukey's range test further revealed that the means for 24th October (24.7°C) and 5th February (23.1°C) were the same, while that of 3rd April (34.7°C) was different from either of them. Therefore we concluded that at about 25°C, temperature had no effect on foraging activity of *A. mellifera*, but at about 35°C, it had a negative one (Figure 4).

e) Effect of Light Intensity on Flight Activity

There was a very highly significant and inverse relationship (r = -0.87; P < 0.001) between flight activity and intensity of light. The point of determination (r2 x 100) was 75.5%, meaning that about 76% of the variation in flight activity could be explained by light intensity. Moreover, the scatter diagram for this relationship (Figure 5) shows that the relationship was continuous and biologically meaningful.

f) Effect of Relative Humidity on Flight Activity

There was no significant correlation (r = 0.275; P = 0.441) between flight activity and relative humidity.

IV. Discussion

As can be seen in Figures 1 and 2, while the pattern of foraging of *A. mellifera* in the study area does not differ among colonies in the same season, it differs between seasons even for the same colony. In a similar study on *A.m. adansonii* in Ghana, Woyke (1992) found that the pattern of activity, in different zones, did not differ much within each season but the pattern of activity, in different zones, differed much between seasons. This suggests that the pattern is influenced by the environment rather than the genetic makeup of the honeybee colonies. Woyke *et al* (2003) in their study on *A. mellifera, A. laboriosa* and *A. dorsata*, in India, concluded that the environmental conditions in which the bees were living for longer period influence their behavior more than their phylogenic relationship. Similarly, Danka and Beaman (2007), working in the U.S.A., found that Russian and Italian bees had a similar flight activity at any given colony size, temperature, or time of day.

The most important environmental factor influencing the pattern of activity of *A. mellifera* appears to be the availability of forage. The dry season pattern, reported in this study, is explained by the dominance of one or a few plants that release nectar and/or pollen at night. Honeybees, being diurnal, exploit these resources near sunrise and sunset times vigorously. In the morning, when they deplete the resources, they fall back on the scanty resources that may be available or they collect water to cool their nests. In the rainy season, on the other hand, forage is usually available throughout the day from a variety of annuals, including crops. For example, the graphs in Figure 1 follow, very closely, the pattern of foraging on *Vitellaria paradoxa*, during whose bloom they were recorded. As reported by Dukku (2010a), honeybees forage on this plant in large numbers from sunset to well into dusk and again from dawn to well after sunrise. Similarly, the pattern in Figure 2 follows, very closely, the pattern of foraging of *A. mellifera* on two dominant plants blooming at the time of the study: *Acacia ataxacantha* and *Guiera senegalensis.* Dukku (2003; 2010b) reported that *A. mellifera* forages on these two plants throughout the day. Furthermore, our finding in this study that flight activity was less variable in the rainy season than in the dry season suggests that the activity of *A. mellifera* is controlled by the availability of forage. Similarly, Pierrot and Schlindwein (2003) concluded that resource availability of the surrounding vegetation seems to be the major factor in defining the forager activities of the stingless bee, *Melipona scutellaris* on a given day.

Our finding that at about 25°C, temperature had no effect on foraging activity of *A. mellifera* agrees with earlier findings. For example, Woyke *et al* (2003) found no correlation between temperature and number of foragers at 18 - 21°C though there was a highly positive correlation at 10 - 16°C. The inverse correlation between temperature and flight activity at about 35°C, reported in this study, agrees with Woyke's (1992) report that at temperatures above 30°C, the number of foragers decreases with the increase in temperature. According to Roman and Weryszko (2006) a temperature of 16-26°C is optimal for foraging by *A. mellifera.*

The inverse correlation between intensity of light and flight activity of *A. mellifera* reported in this study may be indirect or due to the effect of a third factor such as temperature.

V. Conclusion

In conclusion, while recognizing the need for further investigation into this subject, we believe that the availability of forage is the main factor deciding the daily pattern of flight activity of *A. mellifera* in our area of study.

VI. Acknowledgements

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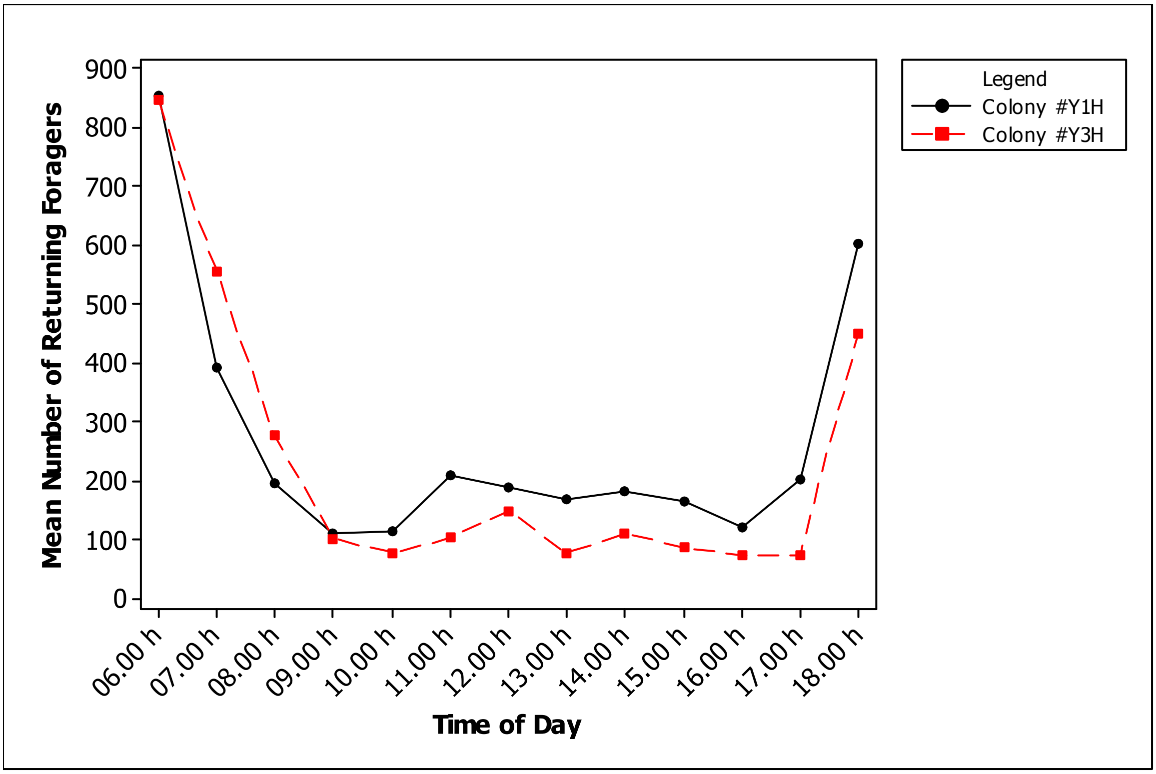

Figure1 : Diurnal flight activity of two honeybee colonies on 5th February 2000 (dry season). The mean number of returning foragers for every hour was obtained by taking the average of two counts taken, during a period of 5 minutes, at the beginning of the hour and 30 minutes later

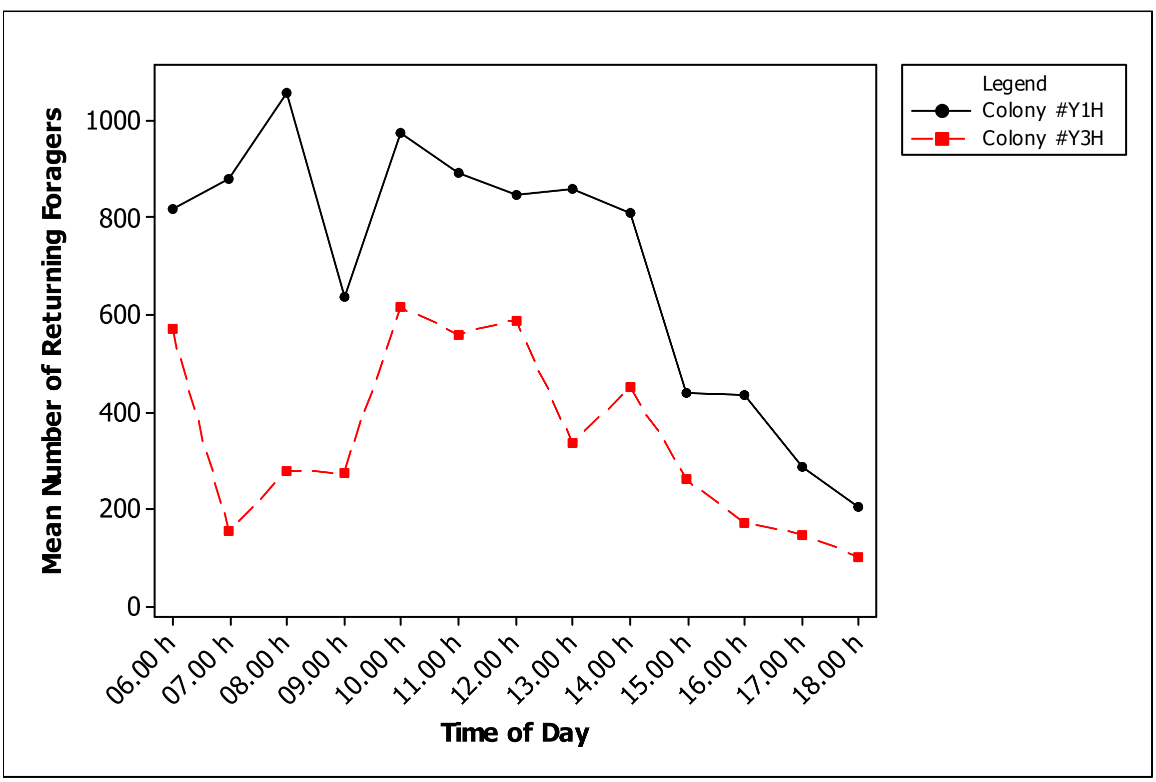

Figure 2 : Diurnal flight activity of two honeybee colonies on 20th August 2000(rainy season). The mean number of returning foragers for every hour was obtained by taking the average of two counts taken, during a period of 5 minutes, at the beginning of the hour and 30 minutes later

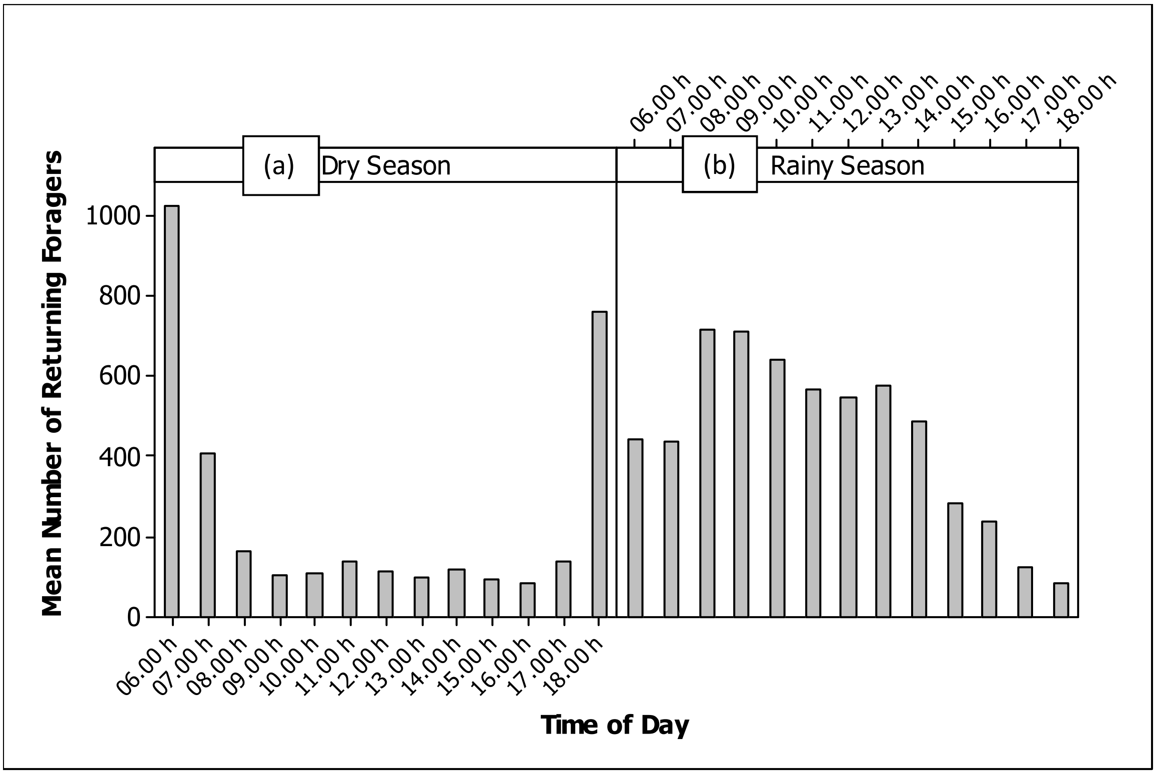

Figure 3 : Diurnal flight activity of honeybee colonies in (a) dry and (b) rainy seasons. The mean number of returning foragers for every hour was obtained by taking the average of two counts taken, during a period of 5 minutes, at the beginning of the hour and 30 minutes later. For each season data of hourly observations taken on five different days were used

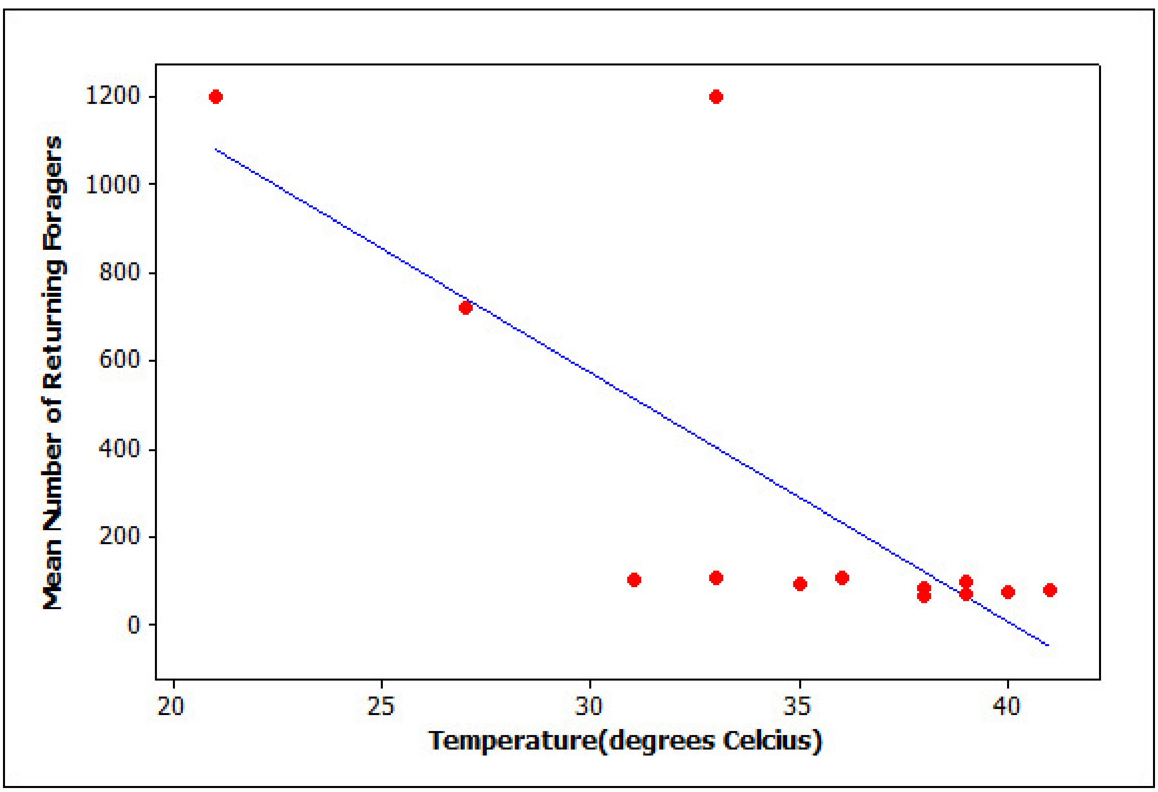

Figure 4 : Relationship between temperature and flight activity of honeybees on 3rd April 2011(mean temperature = 34.7˚C)

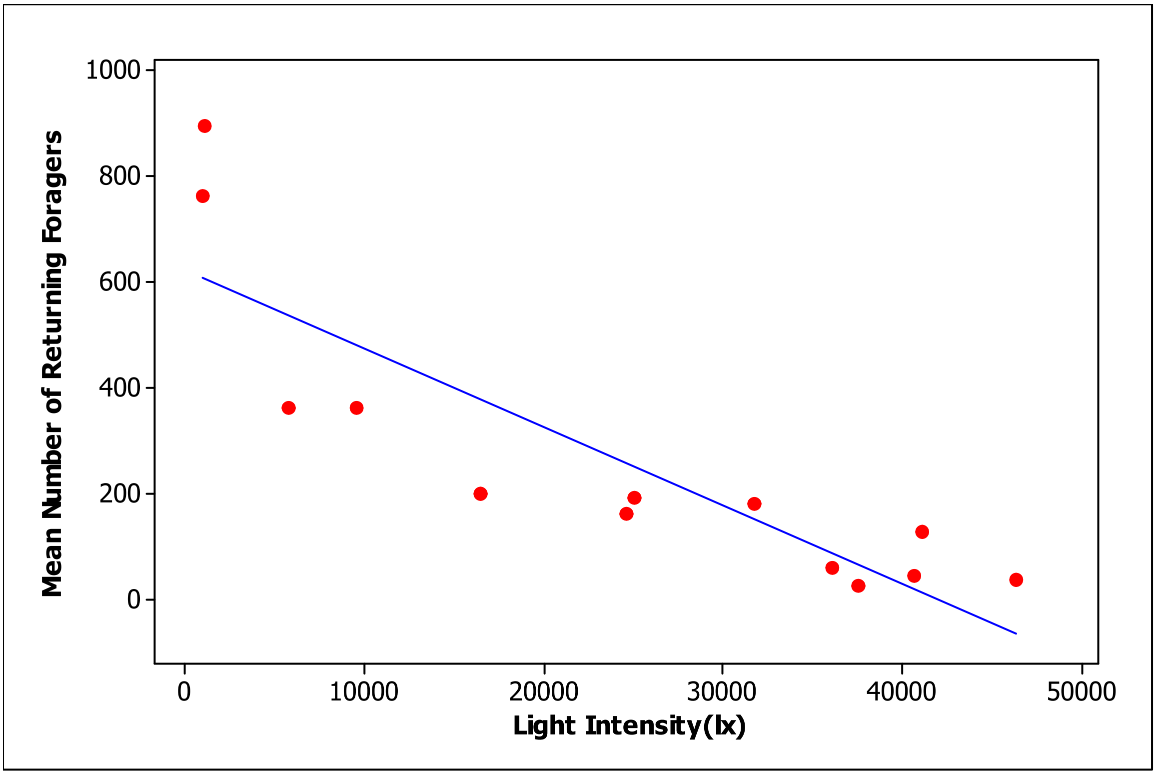

Figure 5 : Relationship between intensity of light and flight activity of honeybees